

EX PARTE OR LATE FILED

WILEY, REIN & FIELDING

DOCKET FILE COPY ORIGINAL

1776 K STREET, N. W.
WASHINGTON, D. C. 20006
(202) 429-7000

February 2, 1994

DAVID E. HILLIARD
(202) 429-7058

FACSIMILE
(202) 429-7049
TELEX 248349 WYRN UR

RECEIVED

FEB - 2 1994

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W.
Washington, DC 20554

Re: Notice of Written Ex Parte Presentation
PR Docket No. 93-61

Dear Mr. Caton:

Transmitted herewith, on behalf of AMTECH Corporation ("AMTECH"), for consideration in the above-referenced rulemaking, is a paper prepared by AMTECH entitled "Factors Affecting Power Level and Spectrum Requirements for AMTECH-Equipped Automatic Vehicle Monitoring Systems." The paper discusses in detail the design of AMTECH-equipped local-area AVM systems and how that design affects both the selection of power levels, which for proper operation may be neither too high nor too low, and system performance as a function of the frequency separation between readers. The themes of this paper complement the positions AMTECH has taken in its comments in this proceeding.

Pursuant to Section 1.1206(a)(1) of the FCC's Rules, two copies of the paper and this transmittal letter are being filed with the Commission's Secretary.

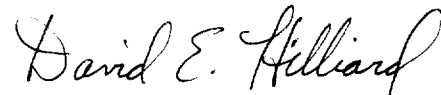
No. of Copies rec'd
List A B C D E

008

Mr. William F. Caton
February 2, 1994
Page 2

Please call the undersigned if there are any questions
regarding this matter.

Respectfully submitted,

A handwritten signature in cursive script, reading "David E. Hilliard".

David E. Hilliard
Counsel for AMTECH Corporation

EAY/ean
Enclosure

cc: w/enclosures

Mr. Ralph Haller
Dr. Thomas Stanley
Mr. Ron Netro
Ms. Rosalind Allen
Mr. Martin Liebman
Mr. Steve Sharkey

**FACTORS AFFECTING POWER LEVEL AND SPECTRUM
REQUIREMENTS FOR AMTECH-EQUIPPED
AUTOMATIC VEHICLE MONITORING SYSTEMS**

February 2, 1994

AMTECH Corporation
8600 Jefferson Street, NE
Albuquerque, NM 87113

***Ex parte presentation
PR Docket No. 93-61***

**FACTORS AFFECTING POWER LEVEL AND SPECTRUM
REQUIREMENTS FOR AMTECH-EQUIPPED
AUTOMATIC VEHICLE MONITORING SYSTEMS**

Several parties participating in the FCC's rulemaking (PR Docket No. 93-61) considering the adoption of permanent rules for automatic vehicle monitoring ("AVM") -- which the FCC proposes to rename the Location and Monitoring Service -- have proffered descriptions of the AVM systems designed, manufactured, and installed by AMTECH Corporation ("AMTECH") with the goal of discrediting the design. As a general matter, these adversarial discussions have relied upon a mischaracterization of the AMTECH systems, both in design and in application. Indeed, these descriptions are inconsistent with those given in AMTECH's pleadings in the proceeding. In the interests of ensuring that the Commission does not rely upon such misinformation, AMTECH has prepared the following further discussion of its AVM technology. This paper focuses on those two areas about which there seems to be the greatest misunderstanding among the commenters: power level and bandwidth requirements for AMTECH local-area AVM systems.

A general description of AMTECH's AVM technology has been included in AMTECH's original comments filed in this proceeding.¹ A copy of that discussion is appended hereto as Attachment A.

¹ Comments of AMTECH Corporation, PR Docket No. 93-61 (filed June 29, 1993), Appendix A, at A-1 - A-6.

POWER LEVELS

As explained therein, one of the defining characteristics of AMTECH's technology is the modulated backscatter of the reader's unmodulated (continuous wave) illuminating signal by the passive tag mounted in or on the vehicle or object to be located and identified. This technique confers certain important benefits from the standpoint of electromagnetic compatibility. Generally speaking, because the tags are merely reflectors and do not radiate, they do not contribute to the overall noise in the spectrum being used.² Further, passive reflection ensures that the installations have a well-confined reading range, allowing the readers to be turned on through the use of a proximity detector only at the approach of a vehicle to be located and identified. Thus, because proper readers are operational only when necessary, their contribution to the noisiness of the band is minimized and consistent with shared use of the spectrum.

² This is the case with both batteryless and battery-powered tag. The primary difference between the two is that the battery-powered tag does not need to draw its energy for its circuitry from the energy of the illuminating signal. As a consequence, battery-powered tags operate at lower field levels, with larger range, and/or at lower transmitted power than batteryless tags, depending on the circumstances of the application. However, in applications involving harsher conditions (temperature extremes, exposure to the elements, incidence and intensity of shock) -- for example the installation of tags on the nation's 1.4 million rail cars -- batteryless operation is favored because it reduces maintenance resources and costs.

Assuming constant power in the transmissions from an AMTECH reader, the received power from a tag reflection at an AMTECH reader is inversely proportional to the *fourth power* of the distance between the reader and the tag.³ This characteristic of modulated backscatter systems is central to their operation because proper location of the vehicle -- critical to ensuring accurate identification -- depends upon ranging that utilizes the returned signal strength of the reflections. As a result, there is no benefit to the user if the readers transmit more power than required, because the higher transmissions increase the radius of the effective reading zone. Concomitantly, higher power increases the odds that another tagged vehicle in the reading zone, but not the desired vehicle (*e.g.*, a vehicle in a lane adjacent to that assigned to the reader, which lane will have been assigned its own reader), could reflect the strongest signal and therefore be the one identified.

This fundamental inverse relationship between received signal strength at the reader and the distance between tag and reader sets AMTECH modulated backscatter systems in sharp contrast with conventional communications systems, for which the received power of transmissions at a receiver is inversely proportional to the *square* of the distance between the transmitter and receiver. This critical difference arises because the AMTECH

³ See "Performance Characteristic of Backscatter AVM Systems" prepared by AMTECH Corporation, appended hereto as Attachment B.

system uses a passive reflector, so that the received power at the reader is the product of two free space attenuations rather than only one, as in a conventional radio system.

This distinction carries with it important ramifications for AMTECH system design and power requirements. As the distance between reader and tag increases from one application to another, the power required, all other things being equal, can be greater than one would expect if one relied upon the inverse square-of-the-distance relationship applicable in free space. Thus, as a rough calculation, if a 100 milliwatt transmit power is sufficient for operation at 15 meters, at 30 meters, 1.6 watts would be adequate rather than the 400 milliwatts one would assume under a free space attenuation.⁴

However, this discussion of received power in modulated backscatter systems only accounts for one of the many factors that must be considered in choosing an appropriate power level for an AMTECH application.⁵ Indeed,

⁴ Of course, this example ignores all other factors relevant to the selection of appropriate power levels, such as the level of the noise background, the length of time in which an accurate location and identification must be made, and so forth.

⁵ In a related vein, it should be noted that the many organizations that have set standards for modulated backscatter automatic vehicle monitoring systems (such as the Association of American Railroads, American Trucking Associations, the American National Standards Institute, and the International Standards Organization ("ISO")) set forth *minimum* specifications. These minimum specifications cannot be presumed to satisfy all users' needs. For example, the ISO's Draft Standard for Automatic Identification of Freight
(continued...)

nothing short of the entire operating environment,⁶ rather than just the distance between tag and reader, must be examined.

For example, at a typical high speed open highway application using overhead antennas, the location and identification of vehicles must be made within an extremely short space of time or the opportunity will be lost. Vehicle lane location must be determined precisely to avoid billing, control, and enforcement problems. A salient characteristic of toll collection environments is that they are rapidly changing: the geometry is not well controlled and the electromagnetic environment is characterized by numerous, fast-moving reflecting objects. Reliable automatic toll collection must ensure that vehicles do not evade the system by speeding, tailgating, and synchronizing arrival in the reading zone with other vehicles, to name a few strategies that might occur to a would-be violator. The key to overcoming

⁵(...continued)

Containers specifies a reading range of 13 meters. This range was deemed to be a minimum requirement for international use. In the United States, however, many container operations use large amounts of land to store containers ("wheeled operations") with a resulting requirement of a large reading range (100 feet or more). In many foreign countries, in contrast, land is at a premium, and containers are stored in compact rows, thus requiring a lower reading range.

⁶ As a general matter, the received signal must be set above the noise level, whether the level is established by receiver sensitivity or external interference.

these environmental complications and attempts at evasion is a controlled reading zone with high discrimination among vehicles.

As a vehicle passes a reader at high speeds, the time available for monitoring, *i.e.*, reading the tag, is very restricted. The reading zone must be well controlled to be compatible with other equipment such as vehicle proximity detection systems (road loops, *etc.*, which ensure that the readers will be transmitting for the minimum time practical corresponding to reliable operation of the AMTECH system), signal lights, informational display signs, gates, and enforcement cameras. The reading zone must also be controlled so that the system can successfully read a vehicle before the vehicle following it enters the reading zone to allow proper operation of enforcement systems. (In a multi-lane situation, events when two cars will pass the overhead reading zone in two or more separate lanes simultaneously -- within 70 ms of each other -- can be expected to occur very frequently.)

On the typical high speed expressway, the lateral separation between vehicles is a little more than 10 feet, and this, therefore, represents about the practical limit for a reading zone along the vehicles' path. At typical speeds of 50 to 100 miles an hour, the window of opportunity for reliable operation is between approximately 70 ms and 140 ms in length. Although in many of AMTECH's current systems, one frame of data can be obtained in a little less than 15 ms, reliable, error-free operation -- critical for toll booths that process

thousands of cars an hour in peak periods -- requires time to scroll through the data approximately four times. Thus, 70 ms is the minimum amount of time needed to make a reliable read in the high speed, open highway application.⁷

In this situation, the energy must be sufficient to power the tag (in batteryless operation) and allow for sufficient reflected signal strength to ensure an accurate read in approximately one-tenth of a second. On the other hand, as indicated earlier, there is no advantage to increasing the power unnecessarily since that would effectively make the reading range larger, opening the door for incorrect reads as more than one car occupying the reading zone at the same time would increase dramatically. Accordingly, while AMTECH employs sufficient energy to ensure reliable operation, there is little if any room to err by increasing the power much beyond that which is necessary. In other words, effective operation from the user's standpoint requires the minimum use of power necessary to achieve the desired level of effectiveness.

The contrast between open highway toll collection and automatic toll collection at a toll plaza is primarily one of degree. Because of somewhat

⁷ In AMTECH read-write systems, higher data rates are achieved, and one frame of data can be obtained in less than 15 ms. However, overall, more frames of data typically must be transferred than in a read-only situation, such that 70 ms is still, as a general matter, the minimum time needed for a successful transaction.

slower speeds associated with automatic toll collection at toll plazas, up to 50 mph, the flexibility in choosing power levels is considerably greater because automobiles are in the reading zone for longer periods of time. As a result, it is even possible that a single reader frequency could be used to monitor two lanes using time sharing or time multiplexing.

Applications other than toll collection present different circumstances that call for different design approaches to meet efficiently the needs of AMTECH's customers. For example, monitoring entrances to and exits from parking garages or restricted areas may be handled with lower powers than in an open highway or toll plaza situation. This is because the distance from tag to reader is smaller, the car is traveling at a much slower speed through the reading zone, and entry and exit may be controlled with a physical gate as well, which will not permit egress until a positive identification of the vehicle is made.

In short, before assessing whether an AMTECH AVM system is employing an appropriate power level, it is necessary to explore the entire set of circumstances surrounding the operation, rather than compare it to another system in a different application. From this perspective, it can be seen that power levels employed by AMTECH devices are not inappropriate or excessive. In fact, it is very rare that a reader-tag system operates at transmitter power levels greater than 2 watts, even where the reading ranges

are several hundred feet.⁸ This level is two orders of magnitude below the 300 watts transmitter power currently permitted under the FCC's AVM rules, and 13 dB below that proposed by the Commission in the current rulemaking.

FREQUENCY SEPARATION FOR LOCAL-AREA SYSTEMS

The basic compatibility concern involving the frequency separation of readers operating simultaneously in the same local vicinity entails minimizing the presence of energy from undesired nearby readers in the passband of the desired receiver. The desired modulated backscatter signal is approximately 50 dB (or more) below the level of the signal being directed from the reader to illuminate the tag. While the desired modulated backscatter signal need be only about 3 dB stronger than an interfering signal, the signal emanating from readers in nearby lanes must be reduced by more than 53 dB in the receiving band of nearby readers. Using frequency separation of 2 MHz ensures adequate separation and, in the current AVM allocation of two 8 MHz sub-

⁸ Generally, under any given operating conditions, only slightly more power is required for a read-write tag, to ensure an economical device and a reliable link. Similarly, high data rate tag operations relying upon greater bandwidth may have greater power requirements, but of the same order of magnitude as read-only tags. In short, with all types of modulated backscatter tags, the primary considerations in determining power requirements are the attributes of the operating environment, not the mode (*i.e.*, read-write or read-only) of operation.

bands, permits the operation of 10 readers in close proximity, and up to twenty if a two-division time division multiplexing scheme is used.

In a toll collection environment, for example, signals transmitted by nearby undesired readers will compete at a particular reader with the weak signal reflected by the desired tag absent adequate frequency separation. As a result, proper selection of reader frequencies in a multi-lane environment is necessary to avoid the obvious problems associated with duplicate or omitted vehicle location and identification.

The need for adequate separation is explained more fully as follows. Modulated reflections produced by tags illuminated by narrowband, continuous wave signals are wideband, although of very low amplitude. The typical bandwidth of these reflections is on the order of 800 to 2000 kHz. The wideband nature of these signals is necessary to preserve the waveform of the modulation and thus achieve good performance and low error rates. As bandwidths are reduced further, performance decreases. In short, wideband reflections are needed to allow the necessary information to be conveyed in the brief period the vehicle is in the reading zone. Typically, the sidebands more than 60 kHz removed from the illuminating carrier frequency are reduced by 10 dB or more from the highest sideband within 60 kHz of the carrier.

In the real world, AMTECH has found that, for RF modules separated by considerable distance, multiple reflections and scattering reduce the effectiveness of the gain of the interfering antenna. As a consequence, little interference has been observed at frequency separations of 2 MHz if the interfering RF module is less than 1/4 to 1/2 mile from the RF module under consideration.⁹ At greater distances, less frequency separation is often adequate.

Within most toll plazas, therefore, separations of at least 2 MHz are desirable for reliable operation. In an open highway situation, the desired frequency separation may increase due to the fact that readers are often located at a greater elevation over the open road, usually 20 feet rather than the 10 or 12 feet in a toll booth.

The discussion on separation between reader frequencies thus far has centered on only one application of AMTECH technology: reflection of a continuous wave signal devoid of information. But users of local-area AVM technology are currently requesting technology solutions for applications that require the reader to transmit information and to demand higher data rates, both of which engender a need for greater bandwidths.

⁹ In some applications, frequencies can be spaced closer. However, the long reading range, high reliability, and low error rates depend in part on redundancy and reflected signal fidelity. As the bandwidth is reduced, signals will be distorted. As a result, range will be lost.

One illustration of such applications soon to be implemented is revenue collection for "closed" toll roads where the tag carries information about where the vehicle entered the road. This data is "written" into the tag by a reader at the point where the car enters. The reader is not continuous wave in such applications but is modulated to carry the information needed by the tag to update its stored data, which is then relayed to the reader at the exit plaza to enable the system to calculate the appropriate toll. Typically, read-write reader-tag systems have necessary bandwidths on the order of 2.0 to 2.5 MHz in order to accommodate the data rate needed in such high speed transactions.

Even higher data rates are being implemented using local-area systems. As AMTECH described in its comments (see also the Comments of the California Department of Transportation, PR Docket No. 93-61 (filed June 29, 1993)), California has adopted a standard for a statewide network of local-area AVM systems that has data rates on the order of 300 kbps. To implement such a data rate and achieve an acceptable measure of reliability, the CALTRANS system, as it has become known, will require multiple channels of 6 MHz bandwidth. The Commission's Notice of Proposed Rulemaking would accommodate only one 6 MHz channel for local-area systems (912-918 MHz). Without multiple channels, reliable operation would be endangered at locations where two or three transmitter installations are

necessary in proximity, as AMTECH illustrated in its comments.¹⁰ Even more problematic is the fact that, even where one installation is sufficient, interference to that installation on the only frequencies available (912-918 MHz) under the Commission's proposal might make successful operation subject to question. This phenomenon is known as "single-point-of-failure."

In order to improve the spectral flexibility for high data rate local-area AVM applications to overcome the difficulties outlined above, while preserving what some wide-area AVM system operators claim they need in order to operate -- a relatively quiet RF environment -- AMTECH proposed in its comments sharing by all AVM systems throughout the 902-928 MHz band qualified by "quiet zones" at 906-910 and 920-924 MHz in which local-area systems would be subject to very strict power limitations. These zones, 4 MHz wide, would accommodate the operations of the wide-area system designer/commenters that filed comments indicating they could not share the same spectrum with local-area systems.

More importantly, from a local-area AVM perspective, sharing in the quiet zones would permit the operation of three 6 MHz local-area system channels simultaneously in the 902-928 MHz band. Specifically, the quiet zones could accommodate the attenuated -- but necessary for successful operation -- sideband power from a wideband local-area system and thus

¹⁰ Comments of AMTECH Corporation at 10-13.

permit a higher data rate than could be otherwise accommodated in the proposed 2 MHz sub-bands (902-904 and 926-928 MHz).¹¹ From experiment and experience, AMTECH has found that wideband pulse ranging systems interfere very little if at all with local-area systems.¹² Thus, the quiet zones permit sharing while limiting the power that could potentially interfere with systems such as those produced by Teletrac.

CONCLUSION

Any consideration about the power levels for AMTECH modulated backscatter systems must take into account all of the circumstances surrounding a particular application. In addition, it is of paramount importance to note that the received power at the reader from a tag reflection is inversely proportional to the *fourth power* of the distance between reader and tag. From this perspective, it will be seen that the powers at which

¹¹ As an alternative to full sharing in the 902-928 MHz band, the 4 MHz quiet zones could be made into wide-area only sub-bands, but the Commission could liberalize the suppression requirements for wide-band local-area systems so as to accommodate operation of systems meeting the CALTRANS standard at the band edges as well as in the center of the 902-928 MHz band.

¹² For example, a paper recently filed with the Commission in PR Docket No. 93-61 describes field results of compatibility tests conducted by AMTECH and Pinpoint Communications, Inc., a wide-area AVM system licensee. See Hatfield Associates, Inc., "Review and Discussion of the Pinpoint ARRAY™ Network and Its Performance," at 6-1 to 6-3, filed as an *ex parte* presentation in PR Docket No. 93-61 on January 24, 1994.

AMTECH systems operate at or near minimum levels. Conversely, AMTECH systems must avoid selecting excessive power levels to ensure successful operation.

Proper operation also requires adequate frequency separation among readers that are situated in the same vicinity, since those transmissions can compete with the weak reflected signals from the tags, which are wideband in nature in order to convey the necessary information from the tag in the small amount of time in which a successful read can be accomplished. As local-area systems become more sophisticated and their applications expand, the demand for greater data rates will require the availability of several wideband channels, up to 6 MHz, within the allocated spectrum. This can be accomplished through sharing between wide-area and local-area systems in the entire 902-928 MHz band and through the creation of quiet zones at 906-910 and 920-924 MHz in which local area systems will be subject to strict power restrictions. Such zones will accommodate the attenuated sidebands of wide-band local-area system operations while providing wide-area systems operators that have expressed some reservations about shared operation -- unfounded in AMTECH's view -- what they in fact have admitted they need, 4 MHz of relatively quiet spectrum.



Attachment A

Description of the AMTECH Technology

Excerpted from "Comments of AMTECH
Corporation," Appendix A, filed in
PR Docket No. 93-61 (June 29, 1993)

I. DESCRIPTION OF THE AMTECH TECHNOLOGY

AMTECH provides an ideal example of how effective technology transfer from the public sector advances the public interest through job creation and beneficial application of technology. Initial development of the AMTECH electronic identification technology began in 1972 as a research project at the Los Alamos National Laboratory in New Mexico. Over the next several years, the Los Alamos team achieved various breakthroughs, focusing on the government radiolocation band at 902-928 MHz. Following a technology transfer from the Department of Energy in 1984, several scientists and engineers left Los Alamos to develop additional, commercial applications for the technology.

In the crucible of the marketplace, AMTECH scientists developed and refined a product for commercial use. This product permits remote identification of, and communication with, vehicles through radio frequency signals. AMTECH holds a broad portfolio of intellectual property protection covering its system design and software.

In general, the AMTECH system has two components: a "reader" and a "tag." The reader consists of a Radio Frequency (RF) Module, antenna, and connections to digital processing equipment. The RF module transmits a low-level radio frequency signal ("unconventional pulsed pseudo doppler radar") using a power level and antenna

designed to control coverage area, always under 500 feet. The tag is an RF passive device.¹ Tags do not transmit radio signals; they contain no intentionally radiating oscillators. The tag is completely silent, i.e., emits no RF energy, when not in the presence of the illuminating signal. However, each tag may be programmed to carry information concerning the object to which the tag is attached.² Pulses transmitted by the reader are modulated and reflected back by the tag. The reflectivity of the tag antenna can be controlled digitally, by varying the efficiency of the antenna. Information stored in the tag's memory is thus used to modulate³ the tags's pulsed reflection. This technology of reflecting energy back to a receiving unit is often described as "modulated backscatter."

The reflected pulsed signal -- which contains a true doppler signal as well as code -- is received and demodulated by the RF Module's homodyne radar receiver. The reader recognizes tags by identification of the code within the signals. The demodulated and amplified signals are passed to the reader for processing. Once data have been retrieved by the system, they must be made useful for the particular application. AMTECH's software gathers, stores, and packages the data, then forwards it for processing. The AMTECH Response Center in Dallas can monitor remotely the data collection process at most of its installations.

¹ Some tags have an internal power source; these battery powered tags have a longer range than do "beam" powered tags since they need not employ any of the received signal energy to power the on-board microprocessor. Like beam powered tags, however, they do not have any radio frequency transmitter.

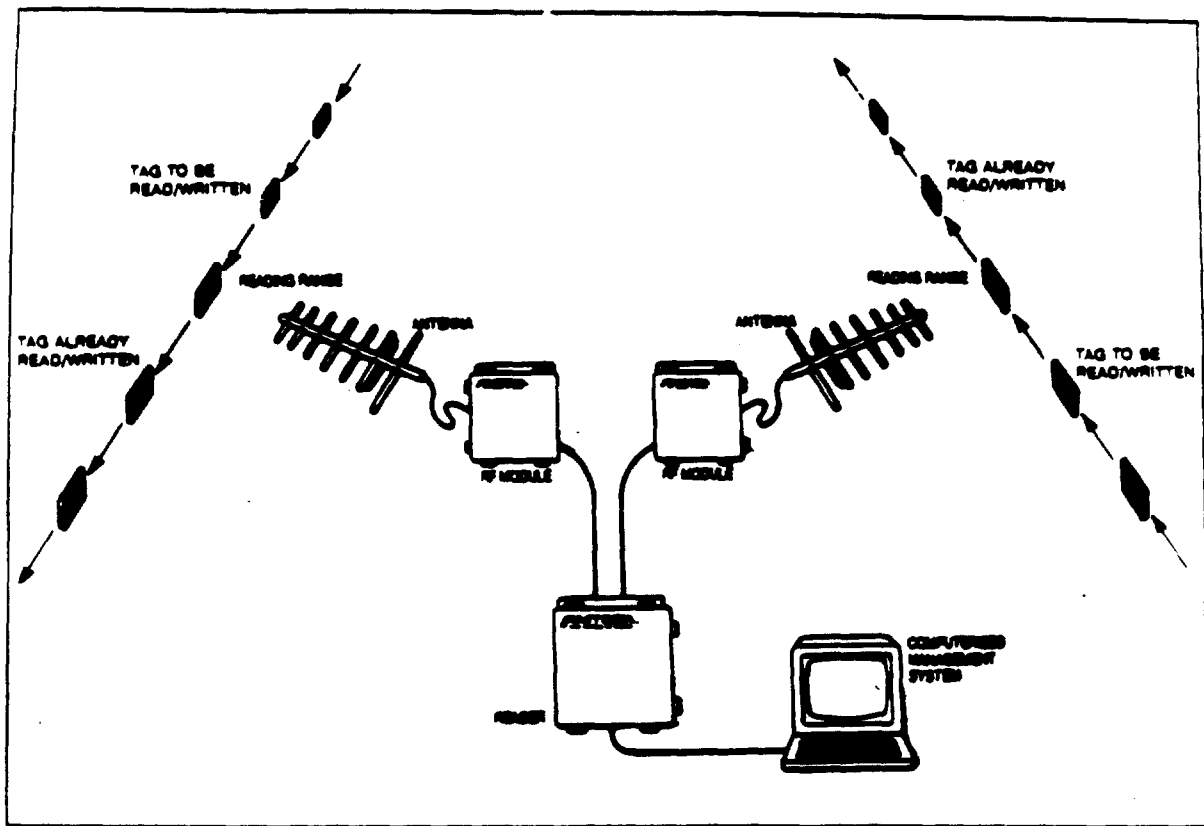
² Many tags are pre-programmed. Other systems use "read-write" tags whose memory can be modified dynamically by the reader system.

³ AMTECH's system uses phase and/or amplitude modulation.

Although AMTECH readers and RF Modules are approximately the size of a briefcase, AMTECH tags can be as small as a credit card.⁴ A diagram showing how a typical AMTECH installation operates is contained in Figure 1 below.

Figure 1

AMTECH AVM CONFIGURATION



The benefits of this type of technology are enormous. The tags are relatively simple in design and, thus, economical. Because the tags do not radiate signals unless

⁴ AMTECH manufactures various models with a range of sizes and shapes.

illuminated, they do not add to background electromagnetic noise levels and cannot interfere with other radio devices such as mobile telephones. The reading zone can be carefully controlled -- far easier than with tags that transmit -- resulting in reliable operations in critical applications. Tag discrimination is precise, and tag detection can be reliably accomplished even in situations where the population of tags is dense (at an automobile toll plaza, for example).⁵

Depending on the application, AMTECH's automatic vehicle monitoring ("AVM") technology uses varying amounts of spectrum. Any single reader in a "narrowband" read-only system (information flowing only from location unit's tag to the readers) requires approximately 20 kHz for its transmission. In a typical installation, this signal is transmitted at approximately 2 watts effective radiated power (ERP) or less.⁶ The tag's modulated reflection is spread over a wider bandwidth, but because the tag is merely a passive reflector, a typical tag reflects less than 300 microwatts. For AMTECH's read-only systems that are currently deployed, the occupied bandwidth is approximately 2.5 MHz and the necessary bandwidth is about 800 kHz. For AMTECH's current generation of read-write systems (information flowing in both directions between the location unit's tag and the reader) the occupied bandwidth is approximately 2.5 MHz.

⁵ The reflected modulated pulse of the tag is measured to determine if the tag is within reading range, allowing the readers to read only those tags passing through their respective lanes.

⁶ The maximum ERP is less than 30 watts. This level of power is employed where longer reading range is needed (e.g., certain rail, highway and intermodal environments).

Most sites require two separate readers using different frequencies, and some installations have as many as 16 or more readers. Reliable operation of multiple readers within a given area requires that readers be separated in frequency and in some cases time multiplexed to avoid mutual interference. Specifically, when readers are relatively close, separations of 1 - 2 MHz are needed between any adjacent reader.

Applications calling for high data rates, such as the recent California Department of Transportation Advanced Toll Collection and Accounting System (ATCAS) regulation, require emissions of greater bandwidth--at least 6 MHz. Thus for toll plazas, intermodal terminals, rail switch yards and multiple, high speed applications such as highways, the AMTECH technology requires access to several megahertz of spectrum, albeit at an extremely low relative power.

The AMTECH system is relatively "simple" in terms of operation and design, in that frequency and power levels are set by the readers (relatively few in numbers compared to tags). At the same time, the tags can be designed to be "frequency agile" so that they respond to a variety of reader signal frequencies. For example, some models of AMTECH tags are capable of responding to reader signals ranging from 850-950 MHz, permitting them to be read in other countries while complying with individual national frequency and power regulations.

Finally, the AMTECH technology is designed to be compatible with other uses of the band. During experimentation and actual experience with nearby ISM products, Part 15 devices, and government radiolocation systems, AMTECH has never experienced debilitating interference from co-frequency users. Moreover, the